AQUA-AEROBIC SYSTEMS, INC.
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PROJECT CASE STUDY

PROJECT NAME AND LOCATION
Grand Ledge WWTP, Grand Ledge, MI

AQUA-AEROBIC SOLUTION
AquaNereda® Aerobic Granular Sludge Technology

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ENGINEER
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CONTRACTOR
RK Davis, Inc.

The Grand Ledge WWTP is located in the City of Grand Ledge, Michigan, approximately 13 miles west of Lansing. The city sits along the Grand River, and is known for its sandstone rock ledges between Island Park and Fitzgerald Park. The rock ledges are frequented by recreational rock climbers, rising 40 feet above the Grand River. Due to continued residential and industrial growth, the City's existing treatment plant is currently at 73% of its present 1.5 MGD hydraulic capacity, and has exceeded its biological capacity. This has hindered development in the area, with the City unable to welcome new businesses due to limited treatment plant capacity.

A plant expansion was necessary to provide the additional required capacity for the current demand and also for future industrial park growth. A 7.8% growth rate over 10 years was anticipated from 2031 to 2041. The existing plant is located within Fitzgerald Park, one of the Michigan Historical Markers. Since this is a notable site for visitors, regulating the impacts to the park during the plant upgrade was crucial.

Upgraded in 1975, Grand Ledge WWTP's existing secondary treatment consists of two aeration tanks with fine bubble diffusers, followed by two secondary clarifiers. Not only did the facility need to expand its hydraulic and organic treatment capacity, but much of the existing infrastructure was at the end of its useful life. An evaluation was done considering a number of alternatives for this upgrade, including expansion of conventional activated sludge, converting to extended aeration and converting to the membrane bioreactor (MBR) process. Despite having the highest overall energy consumption, the MBR was recommended for the design, due to its lowest estimated project costs, net present worth, high-quality effluent to meet anticipated future effluent limits and the ability to fit within the required footprint. This alternative also required the least additional land for plant expansion, and therefore offered the most effective use of the park area.

Figure 1. Existing Grand Ledge WWTP

PROJECT DEVELOPMENT

The design for the plant upgrade was completed in 2022 and was bid in the summer of 2023. The scope of work included new grit removal, screening, micro filters, membranes, new diffusers, blowers, UV disinfection, new solids handling, modifications to existing headworks and demolition of clarifier mechanisms. The low bid was $86.1M, which was $33.8M over the engineer's updated estimate of $52.3M. Due to limited funding, the project rebid early 2024 with few changes. The low bid was $72M, which still exceeded the available funds.

Hubbell, Roth and Clark, Inc. (HRC) assumed the role of consulting engineer, re-evaluating the project alternatives. By the summer of 2024, HRC completed their technology evaluation, recommending AquaNereda for secondary treatment followed by AquaDisk® Cloth Media Filters for tertiary treatment. The project estimate was $52.4M including contingency, which was in line with the previous estimate. It is important to note that the original estimate included retrofitting membranes into the existing secondary clarifiers, and simply upgrading the aeration system in the aeration tanks.

The HRC recommendation, however, involved constructing greenfield AGS reactors. Despite this, the cost estimate was still favorable for the AquaNereda system. This was due to reduced scope, including less mechanical equipment such as smaller blowers, fewer pumps and no mechanical mixers, and the elimination of the MBR building, preliminary filter building and the membranes themselves. Indirect savings consisted of reduced electrical work and wiring and less yard piping. The technology not only offered the lowest construction costs, but also had lower life cycle costs compared to MBR. MBR systems require greater energy use and also membrane replacement within the 20-year operational window. Constructability, operability, and reliability are additional benefits that the City of Grand Ledge will experience.

The project bid one final time in the Spring of 2025, with the lowest bid coming in at $43.3M. Major scope items included new headworks with screening and grit removal, new AGS reactors, tertiary filtration, UV disinfection, reaeration, solids handling and conversion of existing tanks for wet weather storage. RK Davis, Inc. will spearhead the project upgrades as the general contractor.

TECHNOLOGY OVERVIEW

The AquaNereda technology is an advanced secondary wastewater treatment process that utilizes the unique attributes of the granular biomass to perform biological treatment. The technology operates on an optimized batch cycle structure that creates the proper conditions to develop and maintain granules: large, dense microbial aggregates displaying as particles greater than 200 microns in diameter that perform biological nutrient removal and display exemplary settleability relative to conventional activated sludge (CAS).

The superior settling can be quantified by stating that the SVI5 for AGS is comparable to the SVI30 of CAS implying a very rapid settle time that contributes to capacity increases in a given footprint. **Figure 2** provides a visual comparison of AGS and CAS samples after a five-minute settle time. The enhanced settling properties allow the system to operate at high mixed liquor suspended solids (MLSS) concentrations in excess of 8 g/L, twice that of a conventional plant, without a loss in aeration efficiency due to the granular nature of the sludge. The AGS process can therefore provide a significant reduction in both footprint requirements (up to 75%) and energy demand (up to 50%) compared to a conventional technology.

Operating as a batch process, supplementary tanks such as primary clarifiers, secondary clarifiers, and the mechanical equipment associated with return activated sludge and internal recycle are not required. This contributes significantly to the footprint and energy savings. The process uses a three-stage batch cycle structure depicted in **Figure 2**. The initial phase consists of a simultaneous fill/draw under anaerobic conditions. Raw wastewater enters the reactor from the reactor floor through the settled sludge bed with vertical plug flow operation. The dominance of slow-growing bacteria in this phase such as polyphosphate-accumulating organisms (PAOs) encourage phosphorus release.

The second and longest of the treatment phases occurs under aerobic conditions in the bulk liquid and aerobic/anoxic conditions within the granules. Here, reduction of organic constituents occurs in addition to simultaneous nitrification/denitrification and phosphorus uptake. The cycle then ends with a rapid settle phase. A portion of time into settling, sludge wasting occurs at approximately half of the reactor depth.

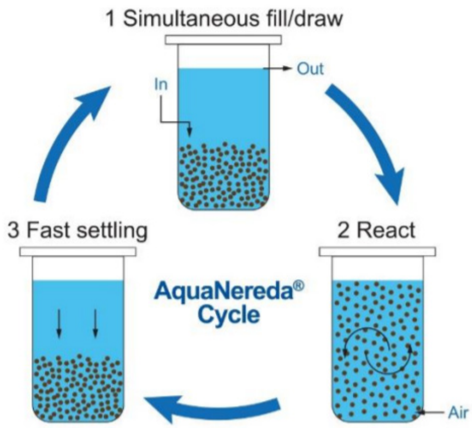

Figure 2. AquaNereda® Cycle Structure

This allows the reactor to waste the lighter flocculent sludge while retaining the denser, fast-settling particles and granules. This hydraulic selection, in addition to the granule backbone developed by extracellular polymeric substances (EPS) during the anaerobic feed, is integral to the formation of true aerobic granules capable of BNR.

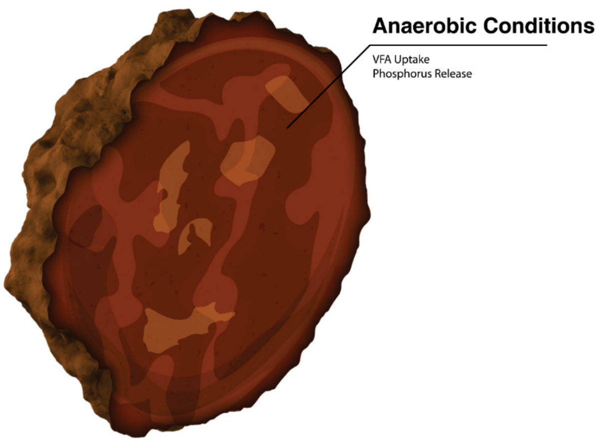

Figure 3. AGS Treatment Zones - Fill/Draw

AGS possesses inherent BNR capabilities as the layered microbial community of the granules enables simultaneous nitrification/denitrification and enhanced biological phosphorus removal (EBPR) to occur within the granular biomass. This technology therefore eliminates the need for clarifiers, carrier media, and return sludge pumping stations, as well as selectors or separate compartments for plants looking to achieve BNR. The granule is predominantly anaerobic during the fill/draw phase of operation (**Figure 3**) then develops distinct aerobic and anoxic zones when aeration is applied to the system (**Figure 4**).

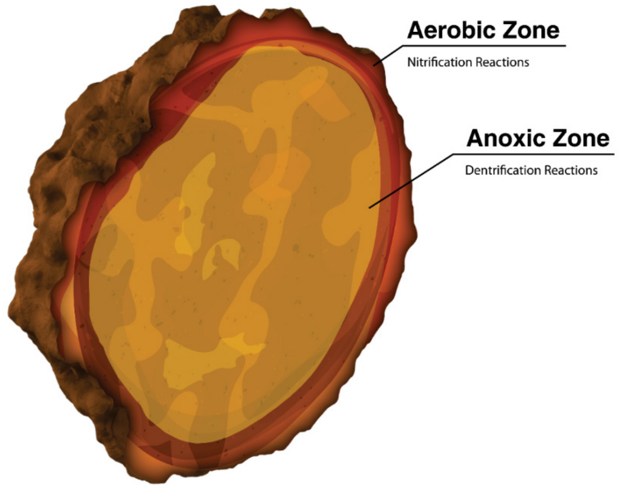

Figure 4. AGS Treatment Zones - React

This layered structure naturally develops as the granulation process progresses through normal everyday operation with the production of EPS forming the backbone of the granule. The granules increase in size and accumulate enough biomass such that the outer layer consumes and depletes dissolved oxygen (DO) before the wastewater reaches the inner biomass via diffusion. EBPR is achieved with phosphorus release occurring during the feed phase under strong anaerobic conditions and luxury uptake occurring during the subsequent aerobic treatment.

SYSTEM DESIGN

The AGS system design consists of three (3) 0.57 MG greenfield reactors and two (2) 32,000-gallon sludge buffers to thicken the flocculent sludge wasted from the reactor prior to solids handling treatment. Three (3) 12-disk AquaDisk Cloth Media Filters follow the AquaNereda reactors for effluent polishing.

	DESIGN INFLUENT	PERMIT LIMITS
cBOD5 (mg/L)	198 (BOD)	4
TSS (mg/L)	225	20
TKN (mg/L)	45	--
NH_3-N (mg/L)	--	0.5
TP (mg/L)	6	1.0

Table 1. Design Criteria

The design criteria for the 3 MGD plant are summarized in Table 1. The design is based on an MLSS concentration of 8,000 mg/L resulting in an F/M ratio of 0.043 lbs. BOD5/lb. MLSS-day. The design HRT is approximately 14 hours long with a design SRT of 26.8 days to provide adequate time for more mature biology to develop for nutrient removal. The basis of design is a 4.5-hour cycle time though this, along with MLSS, is flexible in actual operation to adapt to influent conditions to ensure hydraulic needs are met and healthy F/M ratios are maintained.

CONCLUSION

The City of Grand Ledge required an increase in both flow and biological capacity, and also needed to meet more stringent effluent limits. Following the initial technology evaluation, MBR was recommended for the upgrade. The project bid twice, both times significantly exceeding the project estimate. HRC performed a re-evaluation, and recommended with AquaNereda Aerobic Granular Sludge Technology following by AquaDisk Cloth Media Filtration. AGS offered the City notable project cost savings over the MBR process. The MBR system was designed to fit within existing tankage. The compact footprint and minimal mechanical components of the AGS system demonstrated their value, with the cost estimate being similar despite the AGS reactors being greenfield.

The project bid a third time, with the low bidder $10M under budget. In addition to the upfront savings, the City also estimates lower operational costs relative to the MBR technology, due to lower energy use and fewer maintenance components. The granular sludge will provide the required nutrient removal to meet the plant's permit limits. This site is the fourth installation in the state of Michigan, and demonstrates the cost savings that the AquaNereda technology can offer to North America.

REFERENCES

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